2) Ion chamber-based measurements reported local dose differences (calculated *vs* measured) between 0.2 and 4.8%
3) Dynalog file-based analysis revealed DVH differences below 1% for all the oulined structures when the reconstructed plans were compared to the original plans.
**Conclusions:** Our results show that IMRS plans consisting of fixed beams and a single isocenter can be delivered with high dosimetric accuracy in order to treat multiple brain metastases. This approach probably allows to reduce the treatment time respect to the use of a isocenter for each lesion.

**EP-1314**
**Analysis of prospective individual case reviews completed for the UK head and neck COSTAR trial**
E. Wells[1], D. Gujral[2], A. Miah[2], C. Nutting[2]
[1]*The Royal Marsden, Physics, London, United Kingdom*
[2]*The Royal Marsden, Clinical Oncology, London, United Kingdom*

**Purpose/Objective:** The COSTAR trial (CRUK-08/004) has been open since 2008 and recruited 104 patients to date from 20 UK centres. Prior to recruitment each centre completes a benchmark planning and outlining exercise in accordance with national RTTQA IMRT credentialing processes. The first three cases recruited are then submitted for case review prior to treatment. In order to ensure efficiency and reduce workload for clinical trials personnel, we reviewed this process to determine if further streamlining could be incorporated for future trials.
**Materials and Methods:** The COSTAR trial is a multicentre randomised study of cochlear sparing with IMRT versus conventional Radiotherapy in patients with parotid tumours and is designed to determine the potential of IMRT to reduce the incidence of sensori neural hearing loss. Case reviews have been retrospectively assessed and categorised as to those cases that required minor or major changes to CTV contours, adjustments to organ at risk (OAR) contours,dose prescription errors and unacceptable plans. Minor changes to the CTV were defined as those not likely to affect primary or secondary endpoints of the trial primarily due to the fact that the changes would not impact on the resultant plan that is produced. Major changes were those likely to affect the primary or secondary endpoints and would alter the resultant plan. Two dose prescriptions for the parotid bed were specified in the trial protocol of 60Gy or 65Gy in 30 fractions dependent on the presence of macroscopic residual disease at surgery.
**Results:** Six of the 43 cases submitted for review required replanning: 4 due to incorrect dose prescription, 1 plan was sub-optimal and the final case required major modifications to the CTV and a sub-optimal plan had been submitted. After review of several cases it became apparent that there were more concerns with the contours than the plans so centres were encouraged to submit contours prior to planning. Thirteen cases had outlines submitted for review prior to planning; 3 of these required major modifications to the CTV which prevented the need for repeat planning by a centre. Minor modifications to the CTV were requested for 9 cases. Thirteen of the 43 case reviews submitted required outlining alterations to OARs which would not have impacted on the plan produced but would have resulted in incorrect doses being reported for these organs.
**Conclusions:** The case review process has been shown to be a useful tool in clinical trials as 9 cases submitted required intervention before treatment to comply with the protocol. Centres submitting outlines for review prior to planning streamlines the process by highlighting any contouring errors and preventing replans. It is unlikely that 100% protocol compliance will be achieved for future trials but case reviews can still reveal issues not highlighted during the benchmark process.

**EP-1315**
**Development of a patient-specific collision detection simulator among gantry, couch, and patient for Vero4DRT**
A. Sawada[1], A. Kohnoike[2], M. Moriyama[2], Y. Ishihara[3], T. Shiinoki[4], Y. Miyabe[3], Y. Suzuki[5], T. Mizowaki[3], M. Kokubo[6], M. Hiraoka[3]
[1]*Kyoto College of Medical Science, Department of Radiological Technology, Nantan, Japan*
[2]*Kinki University, Faculty of Science and Engineering, Osaka, Japan*
[3]*Graduate School of Medicine Kyoto University, Department of Radiation Oncology and Image-applied Therapy, Kyoto, Japan*
[4]*Graduate School of Medicine Yamaguchi University, Department of Therapeutic Radiology, Ube, Japan*
[5]*Mitsubishi Heavy Industries Ltd., Advanced Mechanical Systems Department, Hiroshima, Japan*
[6]*Kobe City Medical Center General Hospital, Department of Radiation Oncology, Kobe, Japan*

**Purpose/Objective:** Vero4DRT(MHI-TM2000) has a capability of non-coplanar irradiation by performing RING rotation around a vertical axis as well as GANTRY rotation around an axis perpendicular to the gantry rotation plane. The purpose of this study was to propose a patient-specific collision detection simulator among a gantry, a couch, and a patient for the Vero4DRT system
**Materials and Methods:** 3D surface models comprised of triangular polygons were created based on the Vero4DRT's design for the treatment unit and the couch, respectively. For the treatment unit model, RING rotation around a vertical axis was simulated within an angle range of ±60 degrees while GANTRY rotation around an axis perpendicular to the gantry rotation plane was simulated within an angle range of ±185 degrees. In addition, maximum angular speed was set to 7 deg/sec for GANTRY rotation and 3 deg/sec for RING rotation, respectively. For the couch model, the translation from the isocenter was simulated within a range of ±150 mm in LR, -918 through 682 mm in SI, and -488 through 50 mm in AP directions, respectively. Furthermore, the motion velocity was set to 5-15 mm/sec in LR, 10-50 mm/sec in SI, 5-30 mm/sec in AP directions, respectively. Subsequently, 3D point data of body surface of a patient were acquired using a 3D scanner (Artec MHT, Artec, Luxembourg) with a resolution of 0.5 mm and a frame rate of 15 fps. From the acquired 3D point data, a 3D surface model of the patient was created using Marching Cube method. Furthermore, a decimation technique was applied to reduce the polygon meshes. Next, each 3D surface model was arranged in the virtual treatment room. The collision detection among the above models was performed using a physics engine middleware SDK (PhysX, Nvidia, USA) to be computed on the graphics board. The above simulator was implemented using C++. We have performed preliminary simulation of collision detection among the treatment unit, the couch, and the patient under several geometric conditions.
**Results:** The proposed simulator was implemented on a PC with an Intel Core2 Quad CPU Q9400 2.66 GHz, 4 GB RAM, and a VN220GT-MD1G/D3 VGA board. The rotational function of the treatment unit was simulated with an accuracy of 0.1 degrees for given parameters and that the collision between them was detected (Fig. 1a). Furthermore, the collision maps of the gantry and the ring angles at a couch position were created for simple patient models of different body size (Fig. 1b). The calculation time was approximately three minutes.

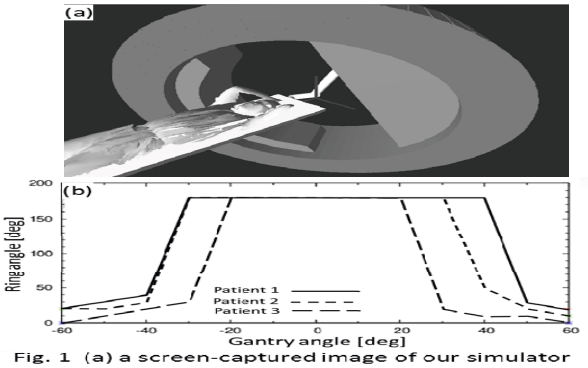


Fig. 1 (a) a screen-captured image of our simulator and (b) a collision map for simple patient models of different body size.

**Conclusions:** We have proposed a patient-specific collision detection simulator among the gantry, the couch, and the patient for the Vero4DRT system using the geometric design and the physics engine middleware SDK. The result suggests that it may be useful for collision avoidance in treatment planning of dynamic irradiation.

**EP-1316**
**Clinical experience with intensity modulated radiation total marrow irradiation (IMTMI)**
B. Aydogan[1], M. Koshy[2], D. Rondelli[3], M. Surucu[4], K. Ahn[5], G. Kavak[6], S. Brett[5], P. Patel[3], N. Ozturk[1], R. Weichselbaum[1]
[1]*University of Chicago, Radiation and Cellular Oncology, Chicago, USA*
[2]*Univ. of Chicago Medical Center, Radiation and Cellular Oncology, Chicago, USA*
[3]*University of Illinois, Hematology, Chicago, USA*
[4]*Loyala University, Radiation Oncology, Chicago, USA*
[5]*University of Illinois, Radiation Oncology, Chicago, USA*
[6]*Cukurova University, Radiation Oncology, Adana, Turkey*

**Purpose/Objective:** We are currently investigating the feasibility of adding total marrow irradiation with a conventional myeloablative regimen of Fludarabine and IV Busalfan prior to allogeneic stem cell transplant. This reports our initial clinical experience utilizing this

novel approach regarding patient setup uncertainty and accuracy in treatment delivery.
**Materials and Methods:** Twelve patients with advanced hematological malignancies were treated according to our institutional phase I clinical trial, which is designed to determine the feasibility and the tolerability of dose escalation using intensity-modulated total marrow irradiation (IMTMI) in combination with Fludarabine/ IV Busulfan in patients with high risk of relapse undergoing allogeneic hematopoietic stem cell transplantation. Patients were immobilized using customized whole body alpha cradle and light cast for the head. All bones excluding the mandible, maxilla,arms and lower extremities were contoured on CT scans and a 3 mm margin was added to obtain the planning target volume (PTV). This method provided greater than 5 mm margin around the bone marrow, which is the clinical target volume (CTV). Organs at risk (OAR) including the brain, lenses, oral cavity, lungs,heart, liver, kidney, rectum, bladder, and small bowel were contoured by the attending physicians. Three separate treatment plans, one for H&N, one for chest, and one for the pelvic region were generated in Eclipse. Plans were optimized for a minimum 95%PTV coverage by the prescription dose. Plan QA was performed with film and ion chamber array analysis. Precise positioning and alignment of all three isocenters were confirmed prior to each treatment with MV port films. Setup errors for each patient were retrospectively analyzed by co-registering port films and reconstructed radiographs using Varian's offline review software.Dosimetric consequences of the determined setup errors were evaluated by shifting the isocenters accordingly. We used Brainlab Exactract kV imaging to treat one patient. A comparison of targeting and dose accuracy was also performed between the MV and kV setup.
**Results:** The setup errors were all less than 5 mm, in vertical (3.2±1 mm), lateral (2.3±1 mm), and longitudinal (3.3±1 mm) directions. When a 5 mm setup error in all directions was simulated, the percent bone marrow that received the 95% of the prescription dose ($V_{95}$) reduced from 99.4%to 97.2% while the median lung dose was reduced from 62% to 58%. We have observed that the kV imaging improved the setup error to be less than 1mm while reducing the setup time more than by half to be 8 minutes per field.
**Conclusions:** Linac-based IM-TMI technique is clinically feasible affording significant normal tissue sparing in a combined chemo-RT regimen. We concluded that a 3 mm bone to PTV expansion was adequate to accurately target bone marrow in IM-TMI treatments and the kV imaging improved delivery accuracy while reducing the setup time considerably.

**EP-1317**
**A comprehensive evaluation of treatment accuracy applied to intracranial stereotactic radiotherapy**
E. Seravalli[1], P.M.A. van Haaren[2], C.W. Hurkmans[2]
[1]*Maastro Clinic, Radiation Oncology, Maastricht, The Netherlands*
[2]*Catharina Hospital, Radiation Oncology, Eindhoven, The Netherlands*

**Purpose/Objective:** To quantify the geometrical and dosimetrical uncertainty associated with the treatment chain of linac-based frameless intracranial stereotactic radiotherapy (SBT) combining end-to-end phantom tests and clinical data. The obtained information is used to assess the adequateness of the employed margin for GTV-PTV expansion and establish action levels for the evaluation of pre-treatment dose verification measurements.
**Materials and Methods:** Data from 55 consecutive patients treated for brain metastases between 2010 and July 2012 at the Catharina Hospital in Eindhoven, the Netherlands were used to quantify the uncertainty associated with: (1) the registration between the planning computed tomography (CT) and magnetic resonance (MR) scans, (2) interobserver variation in target volume delineation, (3) pre-treatment verification measurements with the Delta4 phantom, (4) CT and cone beam CT (CBCT) registration and (5) intra-fraction motion. To assess the overall geometrical and dosimetrical accuracy of the clinical treatment chain, an end-to-end-test was performed that mimicked the clinical procedure, using a phantom with a film embedded (6). This test was repeated on both linacs used for intracranial stereotactic radiotherapy.
**Results:**
(1) Differences in translations and rotations with respect to the average MR-CT registration matrix were on average 1 mm and 0.5°, while the difference between manual and automatic registration was on average 0.5mm and 0.4° in each direction (3 observers, 10 patients).
(2) Interobserver variation in the delineation of the GTV was on average 1 mm and the average GTV center of mass variation was 0.2 mm (3 observers, 12 patients, 16 lesions).
(3) An average 97.5% gamma test pass rate for a (2%, 2mm)-criterion was found for the 38 included pre-treatment dose verification measurements.
(4) Differences in translations and rotations with respect to the average CBCT-CT registration matrix were on average 0.7 mm and 0.5° in each direction (12 patients, 34 fractions).
(5) The mean intrafraction vector length was 0.8 mm (39patients, 81 fractions).
(6) The average displacement vector found with the end-to-end test was 0.9 mm and the average gamma test pass rate for a (2%,2mm)-criterion was 98% for both linacs used for SBT delivery (4 measurements).
**Conclusions:** The uncertainties found for the analyzed steps are in the order of 1 to 2 mm and 1 to 2% dose difference. The 3 mm GTV-PTV margin used in clinical practice is adequate given the measured uncertainties. A (2%, 2mm)-gamma index criterion with a tolerance of 95% can be used to evaluate pre-treatment dose verification measurements. This methodology can be applied to different treatment sites as well to establish the overall treatment accuracy and the adequateness of the treatment margins.

**EP-1318**
**Accuracy of the MLC during delivery of intensity modulated radiosurgery plans: a Dynalog file-based study**
J. Calvo Ortega[1], J. Casals Farran[1], T. Teke[2], M. Pozo Massó[1], S. Moragues Femenía[1], E. Puertas Calvo[1]
[1]*Hospital Quirón, Radiotherapy, Barcelona, Spain*
[2]*BC Cancer Agency, Medical Physics, Kelowna, Canada*

**Purpose/Objective:** To describe the method available in our department in order to assess the accuracy of the dynamic MLC during the delivery of intensity modulated radiosurgery (IMRS) treatments for cranial lesions.
**Materials and Methods:** Cranial radiosurgery treatments can be planned in our department by using intensity modulated technique with multiple fixed fields. Plans are calculated with Eclipse TPS (v 10.0) and delivered with a Varian Clinac 2100 CD equipped with aMLC Millennium 120. Eclipse generates a dynamic MLC pattern for each field to be run by the linac. It is really interesting to know the dynamic MLC behaviour during the delivery in order to determinate the impact of the MLC inaccuracies on the planned dose. Dynalog files (created by the MLC controller during delivery) give a chance to know this impact, as Dynalog files contain detailed information about the leaf position and fractional dose delivered by the linac.Hence, it is possible to reconstruct the 'actual' fluence pattern for each field; an in-house MatLAB code was developed by T.T. for that task. Accuracy of this code was previously checked by using the planned leaf positions instead the actual ones of the Dynalogs files during the MLC reconstruction process. Dose comparison was performed between the original plan and the resulting plan including the reconstructed MLCs. Five typical IMRTplans were used. After each Dynalog-based fluence reconstruction, the corresponding dynamic MLC was imported into Eclipse, replacing the original one and a dose re-calculation of the reference plan was performed (actual plan). Reference and actual plan can be compared by using DHV metric for the PTV and the OARs (brainstem, optic nerves and optic chiasma) , in order to assess the accuracy of the dynamic MLC in terms of its impact on the patient dose distribution. Fifteen cases were analysed in this work.
**Results:** Accuracy of the code developed for generation of dynamic MLC files from Dynalog files was within ± 0.2 %. The accuracy of the fluence delivered by the MLC/linac had an impact of less than 1% on the patient dose distribution respect to the reference plan.
**Conclusions:** The Dynalog-based method used in this work is a useful tool to assess the dynamic of the MLC in terms of impact on the patient dose distribution. This method revealed an intra-session high accuracy of the MLC used in IMRS single-dose treatments.

**EP-1319**
**The effect of linac performance characteristics on IMRT patient dose distributions**
J. Shakeshaft[1]
[1]*Northern Territory Radiation Oncology, Physics, Darwin, Australia*

**Purpose/Objective:** There has been much discussion recently over the optimum way to perform patient specific IMRT QA. It has been proposed that it is possible to project IMRT QA measurements made normal to the beam using an EPID or array back into the patient dataset. This work examines whether applying a correction to this projection process for systematic uncertainties associated with the linac performance makes a significant difference to the dose distribution in the patient.
**Materials and Methods:** The QA measurements from 85 consectutively generated clinical IMRT plans were re-examined. Each plan had had